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The Travel Cost Model: Concepts and Applications

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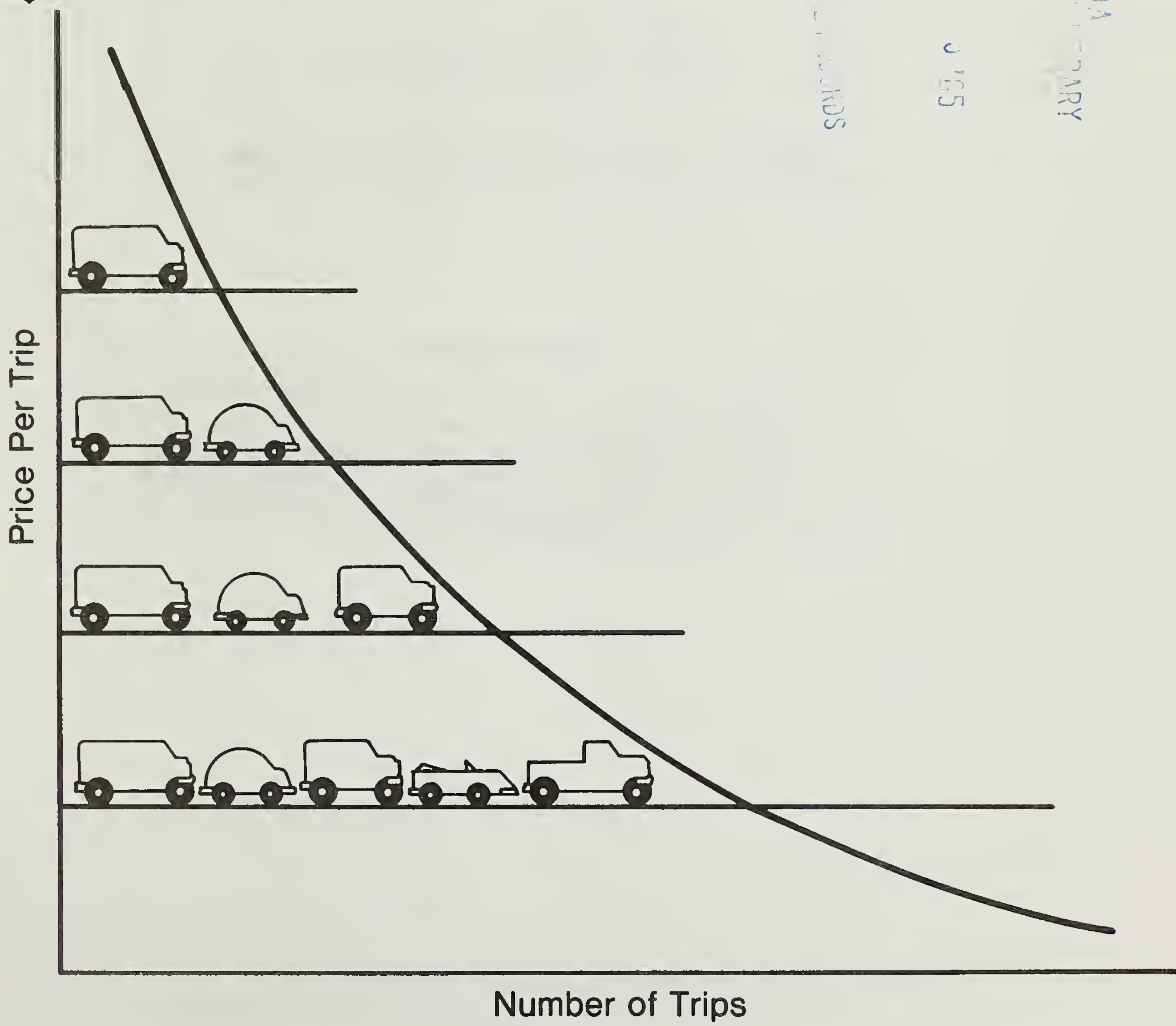

Abstract

The travel cost model (TCM) estimates the demand and supply curves for a recreation site in a manner commensurate with methods used for other resources. Therefore, dollar values estimated by the TCM are comparable to dollar values for other resources. Because of this, the TCM is well suited for use as an analytical technique in the study of recreation planning issues. Issues benefitting from TCM analysis include: the effect of raising entrance fees on visitation, the benefit of constructing a new recreation site, the benefit of modifying an existing site, and estimating use at existing or proposed sites.

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INTRODUCTION

Management of public lands often requires that tradeoffs be made between marketed commodities, such as timber, and nonmarketed commodities, such as recreation. The Travel Cost Model (TCM) of estimating recreation demand can help with these tradeoff decisions. TCM provides information on the economic value of recreation opportunities that is commensurate with marketed outputs from forested lands.

The Resources Planning Act of 1974, as amended by the National Forest Management Act of 1976, requires that attention be given to economic efficiency (i.e., maximizing net economic benefits) in formulating forest plans. The TCM provides a way to bring public recreation services, usually a nonmarketed commodity, into this analysis. Specifically, information provided by the TCM can help to:

1. determine the net economic value of an existing recreation site;
2. determine the net economic value of creating a new site or modifying an existing site;
3. make more efficient allocation decisions among programs;
4. predict recreationists' travel behavior; and
5. forecast changes in the use of a recreation site resulting from charging fees (or changing fees) for using that site.

This paper explains what the TCM is and how it can be used to help manage recreation resources. The conceptual basis of the TCM is emphasized rather than details about how to actually build the model. The discussion of the TCM assumes the reader is familiar with basic microeconomic theory. Readers wishing a review of the relevant concepts from microeconomics should read the appendix to this report. That appendix gives a broad conceptual overview of the TCM within the framework of economic theory. The reasons why value estimates from the TCM are comparable to market prices for other commodities are explained in the appendix.

HOW THE TRAVEL COST MODEL ESTIMATES THE SITE DEMAND AND SUPPLY CURVE

The TCM estimates the demand curve for a recreation site by assuming that the price of consuming recreation at that site varies directly with the distance the consumer is from the site. The reason for the varying price is travel cost. At different prices (i.e., distances from site), different quantities of recreation will be consumed; and these price quantity variations identify the site demand curve.

The rationale of Burt and Brewer (1971) is simplest and most direct. Consider a good that is produced exclusively at a fixed location. Let the consumers of the good be homogenous in all respects except location. Let them be dispersed geographically so that there is wide variation in the cost of reaching the site and returning, i.e., shipping the good to them. Also assume that the price to the consumer is the f.o.b. unit price (i.e., user fee), which is common to all, plus the unit shipping cost, which varies by location. The unit price at location i, p_i, is

$$p_i = p_o + t_i$$

where p_o = f.o.b. price
t_i = unit shipping cost.

Thus, consumers at different locations face different prices because of the geographic variation in t_i. Transportation is simply a production input factor that varies by consumer location. This variable cost is passed on directly to the consumer.

Let the individual demand function for the recreation site for all consumers be the downward sloping line in figure 1. That curve shows the quantity of trips, q, a person will consume during a given time period at the price, p. The horizontal lines in figure 1 are the prices faced by consumers at various locations including the f.o.b. price, p_o, charged at the production site. Observation of p_i and q_i at various locations allows the demand curve to be estimated by appropriate statistical methods. Of course the demand function may not be linear, but alternative hypothesis may be tested and compared. In the case of the TCM, the demand curve in figure 1 represents the site demand curve, and each horizontal line shows the per trip cost of consuming recreation for recreationists living at different distances from the site. For example, the cost per trip of consuming recreation for person 2 is p_2. The demand curve shows that at price p_2, he will consume q_2 units (trips) of recreation from that site at a total cost of $0p_2dq_2$.

These horizontal per unit cost curves (actually supply curves) have nothing to do with the agency costs of providing the recreation site. They simply refer to the cost to the consumer, located at a particular distance from the site, of consuming recreation at the recreation site. A unique characteristic of the TCM is that the supply curve for a recreation site, as faced by the consumers,

varies from location to location. There are many supply curves, not just one. This variation in the supply curve allows estimation of the demand curve in figure 1. Because of the shifting supply curve between locations, points b, c, d, e, and f are observable and can be used in statistical analysis of demand.

The calculation of the net economic benefits to the consumer (i.e., total benefits minus costs incurred by consumers) of a recreation site simply entails adding up the area between the demand curve and the supply curves for the various users of the site. For example, recreationist 2 will consume q_2 units of recreation with total benefits equal to area $0adq_2$, the total costs are $0p_2dq_2$, and net benefit is p_2ad. Similarly, the net benefit to consumer i is p_iac. The total net benefit of a recreation site to consumers is the net benefit to each and every consumer summed across all consumers. The net benefit of the site to society is the net benefit to consumers minus the costs of providing the site plus any receipts from fees. The unique characteristic of the TCM is that the demand curve is assumed to be reasonably common across consumers, but the price faced by consumers varies.

In the case of recreation, the consumer ships himself to the point of consumption, as with many private goods (e.g., shopping centers, movie theaters, etc.). This separates the shipment costs from the f.o.b. prices and creates some potential problems for the model. Because a consumer manages and directly pays the transportation cost, those costs may not be perceived correctly. Demand behavior for recreation will be sensitive to the perceived travel cost. These travel costs may be paid in a variety of ways including monetary expenditure, time, and effort. Identifying the travel costs a recreationist perceives he faces is one of the difficulties in applying the TCM.

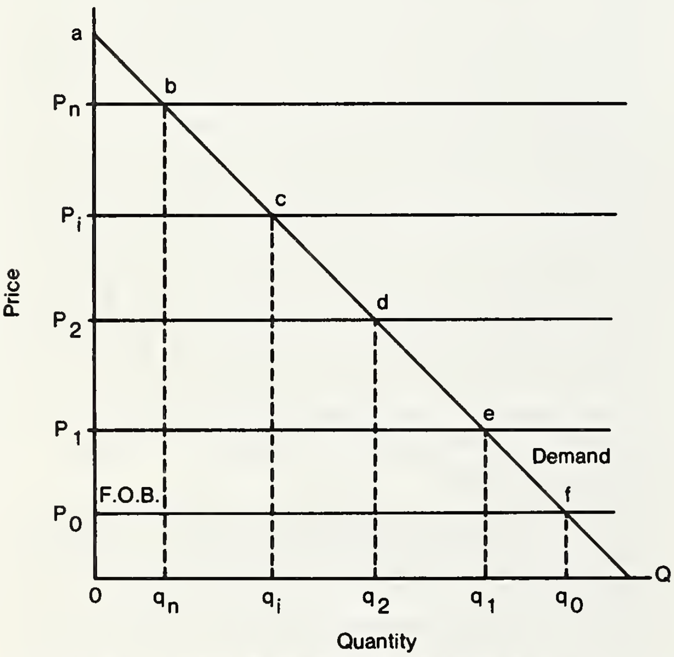

Figure 1.—Travel Cost Model Supply and Demand Curves.

Two additional aspects need explanation. First, there are two types of TCMs: the individual travel cost model and the aggregate model. What has been described above is the individual TCM.

The aggregate TCM is the same, except that people living near each other are grouped into an origin zone. All recreationists living in that zone, a county for example, are assumed to face the same per unit cost. The distribution of tastes and preferences is assumed constant across zones. In the zonal model, the quantity measure is the number of visits or visits per capita, from a given zone. The price for that zone is the average price per visit. Once the quantity measure is put on a zonal basis, the analysis is essentially the same as in the individual travel cost model.

The second point is that the demand equation estimated by the TCM is more general than simply relating price and quantity. Many user characteristics which potentially influence visitation, such as income or education, vary in addition to price. Furthermore, site characteristics will have a significant influence on demand. In its most general form the demand curve estimated by the zonal TCM is:

$$V_{ij} = f(C_{ij}, P_i, S_{ij}, A_j, D_i) \quad (1)$$

where V_{ij} = number of trips from origin i to site j

C_{ij} = cost of travelling from origin i to site j
P_i = population of origin i
S_{ij} = a measure(s) of substitutes to site j for origin i
A_j = a measure(s) of characteristics at site j
D_i = a measure(s) of characteristics of origin i, including income, and education.

This more complicated expression of the site demand curve does not change the underlying concepts related to benefit calculation, but it does complicate the mathematics. The site demand curve is now different for each origin zone.

In addition to being a benefit calculation tool, the site demand curve is an estimating model for recreation use. The general equation can be used to predict visitation at a new recreation site or estimate how visitation at an existing site will change if the characteristics of the site, the admission fee, the population surrounding the site, or access to substitute sites change. When predicted visitation is plotted against hypothetical admission fees, the resulting graph is known as the "second stage demand curve" (Dwyer, Kelley, and Bowes 1977).[3] The use estimating ability of the general equation can be quite helpful when trying to decide how many people a facility should be designed to handle.

[3]The area under the second stage demand curve is also a measure of the net benefit to the consumer of the recreation site. The same estimate of net benefit will always result regardless of whether the procedures discussed in the text related to figure 1 or a second stage demand curve is used to calculate net benefit. This follows because the second stage demand curve is totally determined by the information in figure 1 or, more generally, from equation 1.

Assumptions of the Travel Cost Model

There are two categories of assumptions regarding the TCM. The first category addresses assumptions necessary to ensure that the use of travel costs as a proxy for price is correct. The second category addresses assumptions necessary to statistically estimate the demand curve. If these assumptions are grossly violated, the method is inappropriate and should not be used.

The key assumption necessary to interpret travel cost and travel time as a price of consuming recreation is that one can correctly measure key variable costs that affect trip making behavior. Here variable costs are the costs that vary with distance.

Quantifying variable costs to which trip-making behavior is sensitive is easiest when: (1) travel is incurred exclusively for visiting a site under study; (2) there are not benefits from the travel itself, so that the travel costs and travel time can be used to represent the price paid to visit the recreation site; and (3) the opportunity cost of travel time is known.

If a trip is for many purposes, travel costs are entangled in the joint production of several goods. It may not be possible to assign a portion of the trip costs to a specific purpose. For example, assume one takes a trip to visit friends as well as visit a recreation site. The total cost of the trip or a portion of the costs should not be arbitrarily assigned to the recreation site. The usual solution is to not use that observation as a basis for estimating the benefits of the recreation site. Suggestions have been made on ways to incorporate multiple destination trips into the travel cost model (Haspell and Johnson 1982).

It is commonly assumed that there is no utility or disutility to travel itself. If this is not true, travel cost and travel time do not represent the cost of visiting the recreation site. How to adjust travel cost estimates if this assumption does not hold is partly related to the issue of the opportunity cost of travel time.

Probably the most troublesome issue regarding the TCM is how to value travel time. The value assigned to travel time can markedly affect the benefit estimates derived from TCM. Many authors have discussed issues related to selecting a value for the opportunity cost of travel time (Cesario and Knetsch 1970, Cesario 1976, Wilman 1980, McConnell and Strand 1981). Empirical work reviewed by Cesario (1976) suggests that the opportunity cost of travel time may be between 1/4 and 1/2 of the wage rate. Whatever value is assigned to travel time, it must account for any utility or disutility to travel itself as well as the value of time in its best alternative use.

An analogy to timber production might help clarify the value of travel time issue. When logs are transported, time costs show up as labor costs. Similarly, when the consumer produces recreation trips, the time it takes to travel to the site is a production cost. Therefore, time costs are added to vehicle operating costs when calculating the "price" a recreationist must pay to visit the site.

The assumptions necessary to statistically estimate a travel cost demand function are the same as those required to estimate any other demand function.

1. There is sufficient variation in prices (travel cost) to statistically identify the demand function. This means that recreationists must come from enough different areas of origin to provide a range of distances by which to statistically trace out the demand curve. Violation of this assumption precludes statistical estimation, and, therefore the TCM cannot be applied.

2. All of the relevant variables that affect demand are properly represented in the TCM model (i.e., the functional form is correct). This is a standard assumption in statistical analysis that is necessary to get unbiased estimates of the slope of the demand curve. While the number of possible relevant variables is quite large, only a few make an important difference statistically. Besides travel costs, variables such as income, past experience with this type of recreation, availability of substitute sites, and attractiveness of the site in question, are among those found to be consistently significant or theoretically important. Further simplifying the task is that only variables that vary from person to person (or origin to origin in the aggregate model) need to be included. In the TCM, for example, the presence of bowling opportunities might influence visitation to a recreation site. However, if all zones are assumed to have equal bowling opportunities, this factor can be omitted from the TCM.

3. There is no shortage of the good in question resulting in unsatisfied demand. If, at a given price, there is more demand than supply, some of the demand will be unobserved. For recreation sites, this means that there must be enough capacity to satisfy demand. A technique for implementing TCM when there are capacity restrictions has been outlined by Loomis (1982).

RELATIONSHIP OF TCM TO OTHER BENEFIT ESTIMATION TECHNIQUES

Monetary Valuation of Timber, Forage, and Water

Brown (1982) describes a theoretical framework for valuing outputs of timber, forage and water yields from public forest lands. The methods presented for valuing those resources are conceptually equivalent to the TCM; however, a few comments regarding the valuation of these resources can be added.

In the case of a perfectly competitive stumpage market, the bid price for stumpage from a specific timber stand is a good measure of the net benefits to the producer of that stumpage. However, often the stumpage market is not competitive. The usual reason for lack of competition is that there is only one mill at which to sell the stumpage. With only one buyer of stumpage, the bid price is apt to understate the net benefits of stumpage. When there is not a competitive market, the value of stumpage is best estimated using the residual value timber appraisal system. That system estimates the net benefits of stumpage by determining the value of final products made from stumpage, which are sold in a competitive market, and deducting the costs of producing those products (i.e., harvesting, hauling, milling), and a margin for profit and risk.

It is commonly acknowledged that grazing fees are administratively set and do not necessarily reflect the value of forage. To determine forage values, the USDA Forest Service uses shadow prices from linear programs (Gee 1981). These shadow prices indicate how much returns can be increased over cash costs if an additional animal unit month is available. While the fee paid is in the $1 to $2 range, the value ranges from $7 to $16 per animal unit month. These shadow prices are commensurate with TCM values, because they both represent net benefit to the user per unit of output (i.e., the user's maximum net willingness to pay for the resource). For both forage and recreation, government costs are ignored when estimating values. Such costs become a consideration when determining appropriate funding levels for different programs.

To estimate the value of water, a variety of techniques are used (Young and Gray 1972). A commonly used technique is "change in net income," which is very similar to the residual value timber appraisal system used for timber. The change in net income approach applied to water calculates how much receipts and costs will change in a given area as the result of additional water supplies. The excess of receipts over costs is the economic measure of benefit. Again, these water values are commensurate with the values for other resources.

Other Recreation Benefit Estimation Techniques

Contingent Value Method (CVM)

The CVM or bidding games represent a different technique to estimate the net benefits to the user of a recreation site. In some cases TCM cannot be used, and CVM is a viable alternative to estimate the net benefit to the user of a recreation site. For example, there might not be sufficient variation in travel distances to an urban park to allow use of the TCM. To estimate net benefits to recreationists with the CVM, recreationists are asked to state the maximum additional fee they would pay before they would stop visiting the site altogether. The answer to such questions is a direct estimate of net benefits to the respondent because the figure given represents willingness to pay to visit a site above current expenditures. The CVM and TCM, therefore, are different methods of measuring the same thing.[4] The CVM and TCM, as normally applied, do not "net out" the agency costs of providing the recreation site. These agency costs must be deducted to estimate the net benefit to society. If a fee is charged at the recreation site, the receipts should be counted as a benefit.

While some people object to the hypothetical nature of CVM and the invitation for untruthful responses, empirically derived CVM values often are below values based on other valuation techniques, such as the TCM or hedonic pricing (Bishop and Heberlein 1980, and Brookshire et al. 1982). The U.S. Water Resources Council (1979), which sets Benefit Cost Analysis rules for the Soil Conservation Service, U.S. Army Corps of Engineers, Bureau of Reclamation, and U.S. Fish and Wildlife Service, indicates that TCM and CVM are the preferred valuation methodologies. Their use is required when recreation use levels or recreation benefits are above certain threshold levels. The TCM uses actual behavior to reveal a demand curve and estimate net benefits whereas CVM uses surveys of users to estimate net benefits. If CVM is used, the survey questions must be carefully worded and administered so as to avoid biased or meaningless answers.

Administratively Assigned Values

The other approach discussed by the U.S. Water Resources Council is Unit Day Value (UDV). Much like the USDA Forest Service's values for recreation, these values are administratively agreed upon measures of net willingness to pay for a particular type of recreation. In the case of the UDV, the analyst applies criteria related to quality, location, type of recreation opportunity, etc., to select a value. Administratively assigned values, while not conceptually different, are crude approximations, because there is little empirical support for using one set of values rather than another. If the same value is uniformly applied to all sites, it is much like saying an "automobile" is worth $10,000 regardless of whether it is a Cadillac, Rolls Royce, Volkswagen, or Ford Pinto, and regardless of whether the user must travel 10 miles to buy it from a dealer or 2,000 miles to pick it up at the factory. In addition, the criteria used to vary the value from site to site have been criticized for lack of empirical support and subjectivity in applying them (Dwyer, Kelly, and Bowes 1977).

Gross Expenditures

This method uses the sum of all expenditures incurred by the recreationist as the value of the visit to site. There are several reasons why this is incorrect. Knetsch and Davis (1966) state, "Gross expenditures do not indicate the value of the losses sustained if the particular recreation opportunity were to disappear, nor do they show the net gain in value from an increase in a particular recreation opportunity." Gross expenditures only indicate the amount of money going into recreation support sectors of the economy resulting from availability of this site. If the site were closed, the same expenditure might be shifted to a different site or leisure activity. Thus, the flows of money might not be lost to the economy, just shifted from one area or sector to another.

Use of gross expenditures as a measure of value leads to maximizing inefficiency instead of efficiency. That is, if gross expenditures are a measure of value, new recreation sites should be located as far away from population centers as possible, so that people have to incur large expenditures to get there. This is unwise, because the travel costs saved by locating a site closer to major population centers could be spent to purchase other goods that also provide enjoyment. Use of the TCM allows for travel cost savings to show up as increased site benefits.

APPLICATION OF THE TRAVEL COST MODEL

Benefits from Construction of a New Site

Assume that the construction of a new campground is being considered, and one criterion to be considered in the decision is benefit-cost analysis. In this context, the benefits of constructing the campground include the value of the camping experiences that will be provided at the campground, as well as the value of enhancements to experiences provided at other campgrounds where reductions in congestion may have resulted from use being shifted to the new campground. Costs include what must be foregone in order to provide the camping experiences, including construction and operating expenses for the campground, and outputs that must be foregone for the area influenced by the campground such as possible reductions in the output of timber and noncampground based recreation. Other changes in the value of forest outputs that are expected to result from the construction and operation of a campground also should be evaluated.

For the purposes of this report the discussion is limited to assessing the benefits of the construction of the new site that accrue at the new site. Readers interested in the condition under which one does and does not take into account the effects on existing facilities of introducing a new facility should consult Cesario (1980) or Knetsch (1977).

The basic travel cost model is an equation that predicts visits from particular origins to the site. As such, it includes those variables that are expected to influence site use including distance to site, site characteristics, and the availability and characteristics of substitute sites. In evaluating the benefits of a proposed new site, the first decision is whether or not to employ an existing model. If an existing model is employed it is important that the model (i.e., the equation that predicts visits from particular origins to the site), be applied to the proposed campground, and not the values per visit or day derived from its application to another site. The values derived from application of a travel cost model to a particular site depend on the characteristics of that site, the alternatives that are available, the population of the market area, and the location of the market population with respect to the site and alternative sites. Because all of these factors vary from site to site, the dollar value derived from application of the model at one site is not appropriate at another site, unless the two sites are very similar in all of these respects.

Estimating the model involves considerably more work and expertise than using an existing model. If a suitable model has already been developed, then it may be used to estimate use and value. When estimating a TCM model a variety of statistical and theoretical issues need to be addressed. While these issues are not overly complex, using an existing model simplifies matters.

In selecting a TCM equation to estimate the willingness of users to pay for the use of a proposed site, it is preferable to choose a model estimated for a similar site or set of sites in the same region as the proposed site. That model should reflect the influence of alternative sites and the characteristics of the campground and surrounding areas on the willingness of users to pay for the use of the site. If the model does not include the site characteristics, then it is essential that it was estimated for a site with similar characteristics to the one being evaluated. If the model was estimated for a site that did not have substitutes, extreme care must be taken in applying it to a site that has substitutes. For an illustration of adjustments in the model that might be made in this case see Knetsch (1977). If adjustments are not made, the value of the proposed site will be misestimated; omitting substitutes from the model can result in either over- or under-estimating the value of the site.

If, after reviewing the literature and checking agency records for available models, a suitable model is not found then a new one must be estimated. The reader is referred to Dwyer et al. (1977) for details on estimating a new model.

The TCM estimates the value to users of the new site, given the existence of other sites. Specifically, the total consumer surplus estimate from the TCM model is an estimate of the willingness of users to pay for the site over and above the travel costs they incurred in getting to the site and any entrance fees charged. The TCM estimates are the total benefits minus costs which are incurred by users of the recreation site. The greater the number of substitute sites and the closer those sites are to the one being proposed, the lower the proposed site's value is likely to be. The TCM model, therefore, estimates the value of a recreation site at the margin.

The construction of a new campground may reduce the use of nearby campgrounds. If these other campgrounds are heavily used and congestion is reduced by the creation of the new site, the increase in the willingness of users of those campgrounds to pay resulting from that reduction in congestion should be considered as a benefit of the newly constructed campground. These changes in benefits at other sites ordinarily would not be estimated by direct application of travel cost models. Conversely, the creation of a new recreation site may increase congestion at adjacent sites. This increase in congestion at neighboring sites should be considered a cost in terms of the newly proposed project. However, if the new site affects only the quantity of use at other sites, and not quality, the change in benefits at other sites should be ignored (Cesario 1980).

Losses in the value of timber and other outputs expected to result from construction of the new site also should be considered as costs. The cost may take the form of decreases in the value of timber sold because of higher harvesting costs incurred as a result of efforts to protect the campground and surrounding areas. The values assigned to these losses, which should be in the form of stumpage prices, can be estimated from timber sales in the area or using timber sale appraisal procedures.

Change in Benefits and Use for Modification of a Site

To estimate the change in benefits associated with the modification of a site, it is necessary to estimate the benefits with and without the modification. This can be done

by developing a single TCM equation estimated over a wide range of site conditions and including variables that reflect the proposed modification. The model would be solved with and without the modification and the results compared. Alternatively, two travel cost models could be used, with one predicting the value without the modification and the other predicting the value with the modification. The difference between these two values would be attributed to the modification.

Value of Trip Versus Value of an Activity

A person who visits a recreation area normally participates in many different activities. For example, a visitor to a USDA Forest Service campground might hike, fish, swim, picnic, as well as camp. The TCM gives an estimate of the value of the entire trip, not specific activities. The normal application of the TCM gives no information about which specific activity created the value. Value probably was contributed by all the activities.

In recording recreation use, government agencies often estimate the number of visitor-hours or recreation-visitor-days (RVDs) of different types of activities. Inconsistent bookkeeping creates a problem. Using TCM trip values to estimate the value of an RVD for a particular activity when several activities were engaged in is incorrect. Because trips often involve multiple activities, apportioning the entire trip value to various activities is very difficult, if not impossible, to do without additional information. If all the value is assigned to one activity (e.g., major trip purpose), the value of that activity will be overstated. The simplest solution is to report values as the value of a trip to a certain site.

As a tangent, the simple TCM also gives no information on what proportion of the value of a trip was produced by nature versus what was produced by management. Again, the way to get this information is to include management characteristics in the demand equation. Unless this is done, TCM says little about the efficiency of investing money to change the management characteristics of a site. Of course, if the recreational use of an area is to be eliminated (or created), this information is not needed as the total value will be lost (or gained).

Use of Travel Cost Models to Estimate Revenue and Quantity Changes for Price Increases

Travel cost-based demand curves have been estimated primarily for predicting the willingness of users to pay for the use of a site. For that purpose, it is necessary for the area under the estimated site demand curve to closely approximate the area under the true site demand curve. With increasing interest in pricing as a management tool, attention has turned toward the use of demand curves to predict changes in use and revenue with various levels of entry fees. For this purpose, it is important that the estimated demand curve closely approximate the true demand curve in the lower right section (i.e., at low entry fees).

Limited experience suggests that some of the travel cost-based demand curves estimated with prime attention to the area under the curve may not be highly useful for predicting responses to small increases in the prices charged for the use of recreation sites. It seems that these curves estimate very large reductions in site use with small increases in fees—something that does not usually happen.

One possible explanation for this discrepancy is that the single site TCM predicts quantity decreases if the prices at the site in question are raised and all other prices remain constant. In reality, an agency usually raises prices for an entire system of recreation sites. This affects the price of substitute sites, and, as a result, the decrease in use at any particular site will be less than predicted by a single-site TCM. More experience with the TCM, especially regional TCMs, in conjunction with pricing is needed to assess the ability of TCM to accurately predict quantity decreases from price increases.

CONCLUSION

The TCM gives estimates of the net economic benefits to the user of a recreation site. More specifically, the TCM estimates the willingness of users to pay for the right to use the recreation site over and above their existing costs. Agency costs of providing a recreation site are not deducted from the net benefit estimates. The techniques used to develop value estimates for recreation are entirely commensurate with techniques used for other resources (Brown 1982).

There is no problem in comparing market price to average consumer surplus. In all cases, the area between the demand and supply curves for the project or good in question is a measure of net benefit. If the net benefits of a project are divided by the quantity of output produced by that project, the resulting number is the net benefit per unit of output. As discussed in the appendix, net benefits are calculated in a similar manner for all outputs.

The TCM identifies the demand curve for recreation sites by utilizing price-quantity variations from different persons (or origins in the zonal travel cost model). The value estimate of the TCM indicates the value of a recreation site to users, given that all other sites exist as substitutes to that site.

The TCM may be used in a variety of circumstances. Most important, it can be used to help make resource allocation decisions concerning what is the best use of a given parcel of land. In employing the TCM, it is not always necessary to estimate a new model for each given recreation site. In many instances it is possible to employ the TCM demand equation estimated at another recreation site to determine the value of a different site. It is important that the model be used at the new site, as opposed to the values generated from the use of that model at another site.

The TCM is far from being precise in all its value estimates. More work needs to be done in the areas of

functional form, value of travel time, multiple destination trips, modeling substitutes, and the regional TCM. However, the state-of-the-art has advanced to the point where useful estimates for the value of outdoor recreation can be obtained.

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APPENDIX

CONCEPTUAL BASIS OF MONETARY VALUATION

In the framework of economic efficiency, resources should be allocated so as to maximize net economic benefits. Net economic benefits are total economic benefits minus total economic costs. Economic benefits and costs are often different than financial economic benefits and costs. The latter are restricted to actual dollars exchanged. Economic benefits and costs include financial considerations but also take into account benefits and costs which are not represented in the marketplace. For example, an economic cost of burning wood to heat a home is air pollution in the surrounding community. This is not a direct financial cost to the homeowner but it is an economic cost to society.

Microeconomic theory indicates that the area under the demand curve for a commodity represents the total benefits of consuming that commodity. If all consumers of the commodity paid their maximum willingness-to-pay (e.g., if units of the commodity were sold by sealed bid and given to the highest bidder), then the area under the demand curve represents the maximum obtainable revenue from such a sale. Similarly, the area under the supply curve represents the total cost of producing the commodity. Therefore the area between the demand and supply curve represents net economic benefit.[4]

These concepts are illustrated in figure 2, which depicts the situation where *d* units of a good are sold at price P_1. The total willingness to pay for those *d* units of a good is the area bounded by *0bcd*. The total cost of providing *d* units of the good is area *0acd*. The net benefit is the shaded area *abc*. The net economic benefits are often broken into two parts—consumer surplus, area P_1bc, and producer surplus, area aP_1c. Figure 2 shows that net economic benefit is simply the sum of consumer surplus plus producer surplus. Producer surplus is actual revenue received by the producer over and above costs. Consumer surplus is the difference between the maximum which consumers would have been willing to pay for the good, and their actual expenditures. Producer surplus exists because some firms can produce products more cheaply than others. With a fixed price, efficient firms receive a surplus. Similarly, consumers who highly value a good are apt to enjoy consumer surplus because they pay the same price as everyone else.

When *d* units of the good are produced and sold at price P_1 the net economic benefit of producing one more unit of the good is zero. This is because the cost of producing one more unit of the good exactly equals the willingness to pay for one more unit of the good. In figure 1, both the cost and willingness to pay for an additional unit of the good are the price at which it is being traded in the market, P_1.

If the demand curve in figure 2 were actually D^1, then there would be little consumer surplus, but price would be unchanged. The steepness of the demand curve above the market clearing price determines the amount of consumer surplus. If the demand curve were a horizontal line at P_1, then there would be no consumer surplus.

[4] For this to be true it must be assumed that all relevant benefits and costs are represented by the curves. For example, when calculating the net benefit of burning wood it must be assumed that pollution is not an important issue or has already been incorporated into the demand and supply curve.

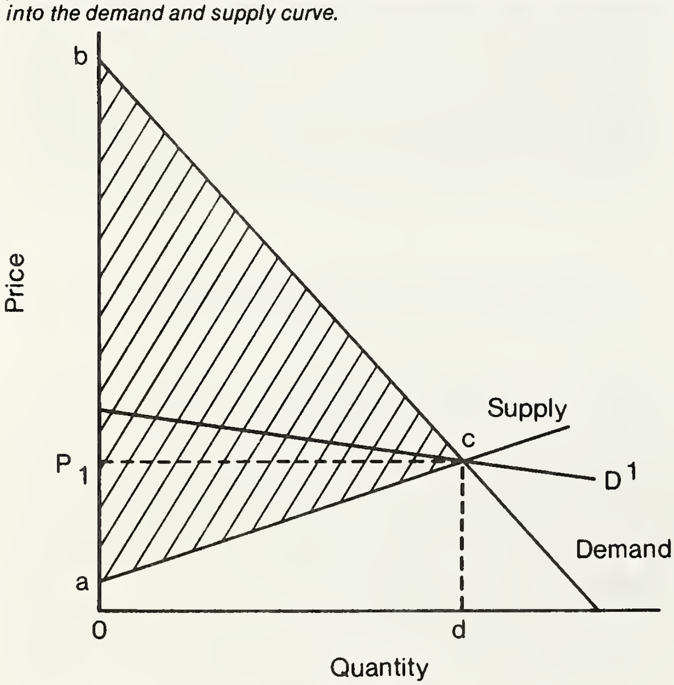

Figure 2.—Demand and Supply Curves.

Slopes of Demand Curves

There are important differences between the demand curve faced by the industry and the demand curve faced by an individual firm within the industry. The left graph in figure 3 shows the industry-wide demand and supply curves which indicate the amount of the commodity that would be demanded by all consumers and produced by all firms, respectively, at particular market prices. The equilibrium price is P_e, when Q_e units of the commodity are sold.

If the industry in question is competitive, then an individual firm within the industry will produce a very small portion of the industry-wide output. For example, in figure 3, one firm might produce Q_eq_s' units of output. If that firm enters (or leaves) the industry the equilibrium price will fall (or rise) slightly so that the new quantity clears the market. If q_s' is infinitely close to Q_e, as is the case in a perfectly competitive market, then the presence or absence of the firm will not affect the equilibrium price. The total benefits of a firm whose output is Q_eq_s' entering the industry is represented by the shaded column in the figure. That area is approximately the market price times the quantity of output (i.e., $P_e \cdot (Q_eq_s')$). The closer q_s' is to Q_e, the more exact the price times quantity measure will be.

If the market is perfectly competitive, then the demand curve faced by an individual firm is a horizontal

line at price P_e, as shown in the right graph in figure 3 (Gould and Ferguson 1980). The major reason for this is that the output from that firm is so small, compared to industry output, that the actions of the firm do not affect the equilibrium price. An individual firm may sell as much or little as it pleases at the going market price. If a firm tries to sell at a price greater than P_e, no one will buy from that firm because there are other firms willing to sell the product at price P_e. This, of course, assumes all firms provide identical products.

When a demand curve is horizontal, the area under it, and hence total benefit, is calculated by multiplying price times quantity (i.e., $P_e \cdot q_s$ in figure 3). If this same area were calculated on the left graph of figure 3, it would be a very skinny column, similar to the one shown. The shape changes because of the different horizontal scales in the two graphs.

The net benefit of production from a single firm is, as usual, the area between the supply and demand curve for that firm (i.e., area aP_eb in the right graph of figure 3). The important points to note are that: (1) there is no consumer surplus associated with the production of a single firm in a competitive industry, and (2) under these conditions price times quantity gives an accurate measure of total benefits.

Under certain conditions, the demand curve for marketed commodity from an individual firm might be downward sloping. First, if the delivery of that product from its point of production to its point of use involves substantial transportation costs, the demand curve is apt to be downward sloping. For example, the demand curve for sand and gravel from a particular site is downward sloping because of significant transportation costs. A sand and gravel firm cannot sell all the materials it desires at a fixed price because transportaton costs greatly limit the amount that distant customers are willing to pay for material at the site. In evaluating the total benefits of operating or creating a sand and gravel operation, a price times quantity measure would not be correct. In that case, the downward sloping demand curve for sand and gravel from that specific site would have to be estimated.

A second case in which the firm demand curve is downward sloping occurs when the output from a specific firm is a substantial portion of the industry-wide output. For example, if stumpage production from a specific timber stand increases output by such an amount that the price of stumpage in an area is lowered, then the demand curve for stumpage from that stand is downward sloping. The greater the price changes, the greater the slope. Demand for stumpage is currently modeled by regions within the country (Adams and Haynes 1980). With this type of model, it is reasonable to assume that production from individual stands on a National Forest does not affect the regional price.

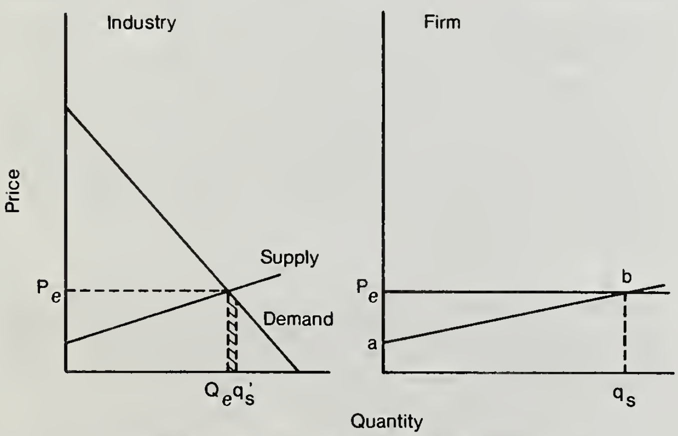

Figure 3.—Industry Versus Firm Demand.

Market Price Versus Consumer Surplus

The question is often raised as to why consumer surplus is used to value recreation opportunities and market prices are used for other commodities such as stumpage. The answer is that net economic benefit is actually being used in both cases. The market structures and pricing policies are different for recreation and stumpage. Therefore, the slopes of demands curves for recreation from a *specific* site versus stumpage from a *specific* site are different.

The stumpage market often, though not always, is assumed to be competitive; so, there is no consumer surplus associated with production from a single site. As a result, net benefit can be calculated as previously described using market price and the supply curve. In contrast, the recreation opportunities from a specific site are not exchanged in a competitive market; therefore, the demand curve and supply curves for a specific site must be estimated to calculate net benefits.

A recreation site has a downward sloping demand curve because travel costs and site characteristics create a distinct market for each recreation site. That is, an opportunity to recreate in Maine is probably not a good substitute for the opportunity to recreate in New York. Creating a recreation site is likely to make large changes in the price of consuming recreation for individuals living around that site. For individuals living reasonably close to the new site, the price of recreating (including vehicle operating costs, time costs, and entrance fees) would be substantially reduced. This reduction in price generates significant consumer surplus for the recreationist.

The shape of a demand curve for recreation from a specific site is better represented by the left graph of figure 3, and the shape of a demand curve for stumpage from a specific site is represented by the right graph. However, the graphs represent extreme cases and two important points must be considered: (1) the true demand curves for stumpage and recreation are not exactly as represented by these extreme cases; and (2) the situation varies from site to site. Nevertheless, this rather extreme contrast between stumpage and recreation curves will be maintained here for illustrative purposes.

In the case of stumpage, the reason the demand curve is horizontal is that in a competitive market there are perfect substitutes for stumpage from that site. The substitute is stumpage from other sites. If there are many bidders for the stumpage in question and many mills

able to sell the stumpage, the market is probably reasonably competitive. In a competitive market, price at the mill (in this case, price is the bid stumpage price per thousand board feet (MBF) plus harvesting and hauling costs per MBF) times quantity (MBF) is a good measure of the total or gross benefits of stumpage from that site. As usual, net benefit is obtained by subtracting total cost from total benefit. Transporting of sawlogs from the harvesting site to the mill entails substantial costs. Because some sites are closer to the mill than others, they will command higher stumpage prices. These higher prices can be counted as a benefit, just as consumer surplus is in the recreation case.

In summary, if the demand curve for stumpage from a site is horizontal, total benefits can be estimated by a price times quantity measure. The slope of the demand curve depends on the market structure. In contrast, because of its downward slope, the demand curve for recreation from a site must be statistically estimated and the area under it calculated to estimate total benefits.

Average Consumer Surplus in a Recreation Model

The net benefits of the goods and services provided by a public project can be expressed as:

$$NB = TB - C_{ag} - C_{pr} + F$$

where NB = net benefits
TB = total benefit
C_{ag} = agency or government costs
C_{pr} = all other private (non-agency) costs, including fees, (e.g., recreationists' travel costs)
F = fees collected for right to use or have the public resource.

As previously stated, the project is worth undertaking if the net benefits are greater than zero. From an economic efficiency viewpoint, a project is worth understanding if:

$$TB - C_{pr} + F \text{ is greater than } C_{ag}.$$

For purposes of this paper, total benefit is equivalent to the maximum willingness-to-pay for the right to use or have a good or service.

Consider the case of a project which produces two million board feet of stumpage from a given parcel of land. Assume that the f.o.b. (free-on-board) price of lumber from the stumpage at the mill in a competitive market is $100 per MBF, and that the cost of harvesting stumpage from the site, milling the logs, drying and selling the lumber, and allowing a normal rate of profit, is $90 per MBF. Based on these assumptions, the total benefits of stumpage from that site are $200,000, and the costs to the operator to receive this $200,000 are $180,000. The net benefits of this project, excluding Forest Service costs, are $20,000,[5] or $10 per MBF. Assuming the road system is already in place, so as to not confuse the discussion with road credits, $10 per MBF will be the competitively bid stumpage price. At $10 per MBF the operator earns a normal rate of return on his investment. This $10 per MBF is producer surplus which accrues to landowners, in this case the government. Alternatively, it may be thought of as rent on the land. It is a payment to the landowner for the right to harvest the stumpage. If the project costs less than $10 per MBF to prepare and administer, it ought to be undertaken, assuming there is no alternative use of the land which would yield greater net benefits.

In the case of recreation, the TCM might indicate that the total benefits are $80,000 and that the costs of producing this $80,000 worth of benefits is $70,000. The costs in the framework of the TCM are entirely travel costs borne by the recreationists. Travel costs are analogous to harvesting, milling, drying, and selling and costs plus a normal rate of profit in the previous example. The net benefit of this recreation site, exclusive of Forest Service costs, is $10,000. This $10,000 figure is what is normally reported in the results of travel cost studies. In other words, the travel costs incurred by recreationists are netted out of the total benefit estimates before the estimates of a recreation site are reported. If this site in question had 3,000 recreation visitor days (RVDs) per year, then the net benefit to the consumer per RVD would be $3.33.

If fees are collected at the recreation site, then receipts can be counted as a benefit. If $5,000 of the $70,000 worth of costs mentioned above were recreation fees, the net benefit of the site would be $15,000. The fee receipts are not consumer surplus, but they can legitimately be counted as a benefit. Similarly, receipts from timber sales are benefit.

The $10 per MBF net benefit for stumpage and the $3.33 per RVD net benefit for recreation are entirely analogous figures. Both are expressions of the net benefit per unit of output produced, without a deduction for C_{ag}. The recreation benefits per RVD are referred to as average consumer surplus, because the source of the net benefit is consumer surplus. Similarly, the source of value for the stumpage is producer's surplus, and these figures could justifiably be called average producer's surplus. However, the simplest way to look at it is that in both cases the figure represents the net benefit per unit of commodity produced, without a deduction for C_{ag}, from a given parcel of land. The rationale for comparing competitively bid stumpage prices to average consumer surplus per RVD is now complete. Of course the argument could be extended to other marketed goods from wildlands, e.g. minerals.

[5]When calculating net benefit the opportunity cost of using the land for a given purpose should be deducted. In this case, if the land could return $5,000 in the next best alternative use, then the net benefit from stumpage production is $15,000.

Rosenthal, Donald H., John B. Loomis, and George L. Peterson. 1984. The travel cost model: Concepts and applications. USDA Forest Service General Technical Report RM-109, 10 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

The travel cost model (TCM) estimates the demand and supply curves for a recreation site in a manner commensurate with methods used for other resources. Therefore, dollar values estimated by the TCM are comparable to dollar values for other resources. Because of this, the TCM is well suited for use as an analytical technique in the study of recreation planning issues. Issues benefitting from TCM analysis include: the effect of raising entrance fees on visitation, the benefit of constructing a new recreation site, the benefit of modifying an existing site, and estimating use at existing or proposed sites.

Keywords: Travel cost model, willingness to pay, economic efficiency, valuation

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Rocky
Mountains

Southwest

Great
Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

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